Portland State University
PDXScholar

Engineering and Technology Management Student Projects

Engineering and Technology Management

Winter 2015

Multidisciplinary Teams as an Enhanced Learing Tool: A Case Study of an Extra-curricular Student Endeavor Resulting in Exceptional Learning Outcomes

Yassir Alamari
Portland State University

Hamed Alyaqout
Portland State University

Qin Guo
Portland State University

Jerrod Thomas
Portland State University

ETM
ENGINEERING & TECHNOLOGY MANAGEMENT

Multidisciplinary teams as an enhanced learning tool

A case study of an extra-curricular student endeavor resulting in exceptional learning outcomes.

Course Title: Communication and Team Building

Course Number: ETM 522

Instructor: Professor Fatima Albar

Term: Winter

Year: 2015

Authors: Yassir Alamri, Hamed Alyaqout, Qin Guo, and Jerrod Thomas

Table of Contents

Abstract

Cross-functional teams are all the rage in business where teams working on new product development can benefit from greater innovativeness and creativity when more diverse work units are put together to develop consumer products [1]. Within the realm of academia, particularly within engineering disciplines, the objectives and interactions of students remains narrow and targeted to the discipline of study. In this paper we look at the potential of enhanced learning outcomes driven by working in a cross-functional or multidisciplinary teams with an appropriate project being available. We examine the role an organically-formed student club played in providing just such a multidisciplinary, business-like project environment in which the participants were challenged to work together and ultimately succeeded in building a real-world product that would not have been possible for any one of the disciplines offered within this technical school.

Introduction

Most students pick a major and plot a course to fulfill the listed requirements as quickly as possible. For engineering students, this is particularly acute as the programs include many required courses and minimal electives, particularly electives outside their area of study (see Appendix A: Blue Sheet of an EE Undergrad). Because of this limited flexibility and exposure to other disciplines, it is important to provide students the opportunity to work with collaborators outside of their normal academic programs. There are several ways that interactions like this might occur, but our primary focus is on a case study at Jubail Technical Institute in the Eastern Province of Saudi Arabia involving the formation of an extra-curricular student group at this technical skills-oriented school.

At this technical institute, a group of students had formed a welding club. As a single-specialty club, the students continued to focus on discussions and tasks within the realm of their academic study. It wasn't until more students became interested in these extra-curricular activities–and students from many different backgrounds came together–that a project with significant complexity and requirements became a potential project idea. As Miller, et. al., said "faculty, and clients overwhelmingly agree that multidisciplinary design teams tend to produce better engineering designs because of the broader range of expertise available to the team [2]."

It is under this premise that we discuss the team dynamics and opportunity for enhanced learning within academic institutions that creating formal opportunities for multidisciplinary or cross-functional teams may provide. By providing more complex projects with many different skills and perspectives, educators can create an effective learning vehicle for real-world experiences and prepare today's learners for the challenges they will face when they enter the workforce.

Literature Review

Multifunctional teams consist of members from different disciplines and functions that have applicable expertise about the proposed problems [3]. For example, a multifunctional product-development team might contain members from finance, manufacturing, operations, marketing, and engineering, plus customer and vendor representatives [4]. Multifunctional teams improve an organization's ability to solve complex problems, while, in the mean time, team members develop technical and professional skills, and learn how to work with people with different styles and cultural backgrounds [3], [4].

Recently, in many high-technology firms, multifunctional teams are playing a critical role in enhancing the collaboration between different departments via appropriate internal communication [5]. It is obviously that through sharing information, a multifunctional team is able to successfully implement projects, thus establishing and maintaining high-performance [6], [7]. For example, a multifunctional team at Amoco's Offshore Business Unit in New Orleans, Louisiana, is made up of geologists, geophysicists, engineering, and computer scientists. Their purpose was to acquire more oil from mature -fields in the Gulf of Mexico. With good interaction, this team substituted more than 100 percent of depleted reserves in 1990, showing excellent outcomes in finding new oil reserves [4]. Multifunctional teams provide the advantages of high absorptive ability since members' various expertise allows them to have multiple sources of communication, information, and perspectives, which are crucial for the high-performance of technology firms in competitive markets [3], [8].

When it comes to establishing a multifunctional team, knowing what the stages are and how to meet the needs of the team at each stage possibly avoid many pitfalls teams seem to experience. As demonstrated in [9], four stages are included to establish a team: forming, storming, norming, and performing. Upon forming a team, members considerately observe the boundaries of adequate team behaviors to assure that "the right people" are "on the bus" [10]. In this stage, such feelings as "pride in being chosen for the team", "excitement, anticipation, and optimism" or "suspicion, fear, and anxiety about the job ahead" are associated with members, which result in possible behaviors, like attempting to understand the task, deciding adequate team behaviors, or discussing irrelevant problems to set a clear goal [9]. The second stage “storming” is possibly the most difficult stage due to the fact that members’ knowledge and skill domains differ as a result of their work experience and education, which occasionally cause negative effect on the growth of a team [3], [4], [11]. When controversies or conflicts occur, it is possible for members to have feelings like anxiety, resistance, and frustration [9]. Teams might fall apart in this stage while a study of 43 multifunctional teams shows that the effect of conflicts on team outcomes depended on how free members felt to express task-related doubts and how cooperatively or aggressively these doubts were expressed [3]. Once members conquer this stage, they will move to the next stage “norming”. During this stage, a team is capable of making significant progress because of such feelings as, a common goal, acceptable membership, and a relief of the work that have been done well [9]. The final stage during the growth of a team is “performing” where members can perform consistently. In this stage, members can create some measures to help the team overcome two predominant obstacles they might have during a project: getting functions to provide expertise to teams when they need it and getting people from various departments to speak a common language [12]. As illustrated by Meyer, “trying to run a team without a good, simple guidance system is like trying to drive a car without a dashboard.” [12] Right measures can significantly improve the team performances while inadequate measures negatively affect the team. Therefore, when creating measures, it is necessary to take some key criteria under consideration. For example, critical objectives must be tracked; monitor for out-of-bounds conditions; track critical variables necessary to achieve goal; eliminate the measurement if results do not create a change in behavior; don’t create too many measurements.

With the competitive nature of the technology industry ever-increasing pace, academia needs to look to the same, particularly with the disciplines that lead directly to technology and new product development job opportunities. Because of this “organizations are turning to project management and relying to a greater degree on project teams for the development and implementation of new products and programs [6].” In recent years, academics have begun reviewing the possibilities of project teams, hands-on projects, and multidisciplinary groupings of both students and faculty to enhance learning [2] [13]. If academics continue this move to the use of cross-functional teams, the “benefits for the students and faculty” will most certainly “outweigh the extra effort that is needed to bring such a course into being. [13]

Case Study

In 2007, two faculty members from the mechanical department of Jubail Technical Institute (JTI) specialized in welding skills started a welding club. This club mainly focused on the welding activities. As the popularity of the club increased, students from a variety of mechanical fields with diverse skill sets started joining the group. The student affairs of JTI saw the potential of the members of the club to do much more things than just welding, and that is when they came up with the idea of the Mechanical Club.

This paper talks about the Mechanical Club, formed in 2012, to develop mechanical projects. The club initially consisted of 11 members including three faculty members and the rest of the group was comprised of students of JTI. This group consisted of eight students from various fields like computer-aided drafting and design, welding, millwright, machining, pipefitting and crane operation. It was this diversity in the club membership that allowed students to work together with those in other skill areas, something the academic tracks did not naturally enable.

Figure 1 - Team Formation, the Welding Club evolves into the Mechanical Club

Figure 2 - Early fabrication and component fitting of the lift mechanism

The club started off with small meetings and discussions about various projects. At the very first part of this project, students came up with unique ideas by the means of brain storming process. By the end of this brain storming session, the club finalized upon the project that they would work upon. Among all the concepts submitted, the club zeroed in on developing a hydraulically powered aerial work platform in the form of a scissor lift [14].

The mechanical club made a decision to design a multi-step process including the research, conceptualization, feasibility assessment, establishing design requirements, preliminary design, detailed design, planning and tool design, and finally the finished concept of the Mechanical Hydraulic Lifter, as the team named it. Each member of the club was assigned a specific task related to his field of specialization.

The process started off with the drafting of the design by each member individually, allowing each student to interpret the project according to the expertise and talents of their respective skills before the final design was finalized by members specializing in AutoCAD® and other design software. This was then followed by the procurement of raw materials. Once received, the machinists began the process of cutting, milling and machining the designed components. Then these parts were welded and fabricated as per the design specifications by the welders and fabricators in the club. The welded parts were then assembled and tested for defects by the millwright students.

This project provided an excellent opportunity for JTI students to gain skills in teamwork, leadership, time management, and applied classroom knowledge to a real-world application that required a multidisciplinary team to complete.

Figure 3 - The finished product

Results and Applications

A multifunctional team can be a great tool for companies, governments, and organizations to face challenges and solve complex problems. There are many applications of multifunctional teams. In the automotive manufacturing industry, a team comprised of psychologists, technicians, market experts, fashion designers, and economists come together to make the best color decision for the interior and exterior of new car models launching in the market. Without this breadth in perspectives and skills, the level of creativity and depth of insights into the consumer desires would not be that high, resulting in a less ideal outcome.

The case in Jubail Technical Institute (JTI) demonstrates the results of joining various technological, functional and professional skills into one team working towards a single, greater goal which led to better outcomes that were more accurate, in a shorter amount of time and required less overall effort. When the Welding Club grew up to become the Mechanical Club, more complicated projects and more challenging exercises became possible. In addition to the enhanced team outcomes, additional learning opportunities were presented: cross-disciplinary teamwork, communication, and project coordination skills were fostered in a real-world setting, providing the students hands-on experience they would have not received otherwise. Multidisciplinary teams and projects such as this demonstrate an "important and successful curricular and pedagogical model for senior engineering students to experience the multidisciplinary nature of "real world" engineering design practice [2]."

Discussion & Future Research

While this case study was illustrative of the potential of a multidisciplinary team, particularly as it came from a totally voluntary source, it seems that more formal institutionalization of hands-on and even more cross-functional engagement could be of even higher value. Schools across the country are engaging in these new methods of learning, providing capstone projects driven by industry partners and educators working in tandem. A review of successful techniques and constructs could be useful for programs looking to start a formalized cross-functional learning segment for their programs. As an interesting postulate, it would be fascinating to review intra-discipline capstone efficacy and outcomes vs. inter-disciplinary capstone outcomes. While defining clear, consistent measure between programs will be difficult, one might consider trying for consistency by sticking with a single University. Portland State University has programs that stretch across colleges such as the "Launch in 9" entrepreneurship program between business and engineering students. The comparison to the more typical electrical engineering, or computer engineering capstone programs that focus on pairing students of the same discipline might be provide a valuable comparison to enhance our understanding of multidisciplinary dynamics in a academic setting.

Conclusion

Cross-functional teams are more creative and frequently more effective than their single-minded counterparts. The use of multidisciplinary and cross-functional teams in business is here to stay and students graduating from engineering programs need to be prepared for the realities of working with highly motivated teams of individuals with varying opinions, ideas, skills, and backgrounds. Communication between team members remains one of the single most important elements in cross-functional team success and by demonstrating and exposing students to the dynamics of cross-functional or multidisciplinary teams while still incubated by the instructive cocoon of their academic careers, we will be able to produce graduates whom are better prepared than their predecessors to take up the challenging jobs awaiting them as members of the modern workforce.

Bibliography

[1] Rajesh Sethi, Daniel C. Smith, and C. Whan Park, "Cross-Functional Product Development Team, Creativity, and the Innovativeness of New Consumer Products," *Journal of Marketing Research*, pp. 73-85, February 2001.

[2] Ronald L. Miller and Barbara M. Olds, "A model curriculum for a capstone course in multidisciplinary engineering design," *Journal of Engineering Education*, vol. 83, no. 4, pp. 311-316, 1994.

[3] Kay Lovelace, Debra L. Shapiro, Laurie R.Lovelace, Kay Weingar, Debra L. Shapiro, and Laurie R. Weingar, "Maximizing Cross-functinoal New Product Teams' Innovatevness and Constraint Adherence: A Conflict Communications Perspective," *Academy of Management Journal*, vol. 44, no. 4, pp. 779-793, 2001.

[4] Glenn M. Parker, *Cross-functional teams: Working with allies, enemies, and other strangers*. San Francisco, CA, USA: John Wiley & Sons, 2003.

[5] Mirghani Mohamed, Michael Stankosky, and Arthur Mur, "Applying knowledge management principles to enhance cross-functional team performance," *Journal of Knowledge Management*, vol. 8, no. 3, pp. 127-142, 2004.

[6] Mary Beth Pinto and Jerrrey K. Pinto, "Project Team Communication and Cross-Functional Cooperation in New Program Development," *Journal of Product Innovation Management*, vol. 7, no. 3, pp. 200-212, July 1990.

[7] Abbie Griffin and John R. Hauser, "Patterns of Communication Among Marketing, Engineering and Manufacturing - A Comparison Between Two New Product Teams," *Management Science*, vol. 38, no. 3, March 1992.

[8] Robert T. Keller, "Cross-functional project groups in research and new product development: Diversity, communications, job stress, and outcomes," *Academy of Management Journal*, vol. 44, no. 3, pp. 547-555, 2001.

[9] Peter R. Scholtes, Brian L. Joiner, and Barbara J. Streibel, *The Team Handbook*, 3rd ed.: Oriel Inc., 2003.

[10] Mary Kay O'Connor and Sylvia Wolf, "The Power of Cross-Functional Teams," *Velocity: Information to Speed Past the Competition*, vol. 6, no. 3, pp. 32-37, 3rd Quarter 2004.

[11] Gerben S. Van Der Vegt and J. Stuart Bunderson, "Learning and Performance in Multidisciplinary Teams: the Importance of Learning and Performance of Collective Team Identification," *Academy of Management Journal*, vol. 48, no. 3, pp. 532-547, 2005.

[12] Christopher Meyer, "How the Right Measures Help Teams Excel," *Harvard Business Review*, pp. 95-103, May-June 1994.

[13] Alexander Thomson, "Faculty collaboration: Creating multidisciplinary learning communities," *Community College Enterprise*, vol. 13, no. 2, 2007.

[14] Wikipedia. (2015, Jan.) Aerial Work Platform. [Online]. http://en.wikipedia.org/wiki/Aerial_work_platform

Appendix A: Electrical Engineering Undergraduate “Blue Sheet”

Department of Electrical & Computer Engineering
Electrical Engineering General Program
Possible 4 Year Course Plan

	FRESHMAN FALL	FRESHMAN WINTER	FRESHMAN SPRING	SOPHOMORE FALL	SOPHOMORE WINTER	SOPHOMORE SPRING	JUNIOR FALL	JUNIOR WINTER	JUNIOR SPRING	SENIOR FALL	SENIOR WINTER	SENIOR SPRING
Math / Science Requirements												
	CALCULUS I MTH 251	CALCULUS II MTH 252	LIN ALG MTH 261	DIF EQ I MTH 256		CALC IV MTH 254	Math/Sci Elective		Applied Statistics STAT 451	This form is meant as a guide only. For their junior and senior years, Electrical Engineering majors must select a specific track from the following list: analog/RF digital/VLSI electromagnetics microelectronics power signal processing		
	CHEM I CH 221			PHYSICS PH 211/221 214	PH 212/222 215	PH 213/223 216						
	CH 227											
Engineering / Computer Science Requirements												
	EXPLOR ELEC ECE 101	ENGR COMP ECE 102	ENGR PROGR ECE 103	ELEC CIRCUIT ANALYSIS I ECE 221 221L	II ECE 222 222L	III ECE 223 223L	ELECTRONICS I ECE 321 321L	II ECE 322 322L	III ECE 323 323L	Track senior electives 4XX ECE 4XX	ECE 4XX	ECE 4XX
		DIGI CIRC ECE 171			DIGI SYST ECE 271 ECE 271L		MICRO PROC ECE 371	Fourier Analysis ECE 312	Feedback & Control ECE 311	ECE 4XX	Start MS program	
							Eng. E-mag. I ECE 331 ECE 331L	Eng. E-mag. II ECE 332 ECE 332L	ECE Track Elective	Industry Design Proc ECE 411	Senior Design Dev. I ECE 412	S.P.D. II ECE 413
General Education Requirements												
	FRESHMAN INQUIRY UNST 1XX	UNST 1XX	UNST 1XX	SOPHOMORE INQUIRY UNST 2XX	UNST 2XX	UNST 2XX		TECH RPT WR 327		CLUSTER: PRIV PUBLIC INVEST EC 314U	UNST UPPER DIVISION CLUSTER	UNST UPPER DIVISION CLUSTER

EXPLANATION		
CREDIT HOURS		2014-2015
1	Refer to PSU Bulletin for General Education Requirements	Portland State UNIVERSITY Maseeh College of Engineering and Computer Science
2	See http://www.pdx.edu/ece/course-plans for available tracks and their requirements	
3	CORE ADMISSION REQUIREMENTS JR ELECTIVE SR ELECTIVES GRADUATE PROGRAM	
4		